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Relationship between intramuscular fat content and fatty acid composition of pork

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Abstract

This study aimed to determine the relationship between intramuscular fat (IMF) content and fatty acid (FA) composition of pork. The IMF content and the FA composition were determined in the samples (n = 30) of muscle tissue (*m. longissimus dorsi*) taken from the pig carcasses from the intensive pork production system in Republic of Croatia. The fat content was analysed by standard ISO method, while FA composition was determined by liquid gas chromatography using the in situ transesterification method. Results revealed the significant positive correlations and regressions of monounsaturated FA (MUFA) on IMF content, while reverse relationship existed between IMF and the most of the polyunsaturated FA (PUFA). Although there was a significant relation between the IMF content and the majority of individual saturated FA (SFA), the effect of IMF content on the proportion of total SFA in pork was not clear. This can be explained by the existence of significant correlations and regressions but with an opposite directions for major SFA-s, which shares in IMF were simultaneously increasing (e.g. 16:0) and decreasing (e.g. 18:0) with an increase in IMF content.

Keywords: correlation, fatty acid, intramuscular fat, pork

Introduction

Of all types of domestic animals for fattening, pigs have the highest degree of accumulation of fat tissue in the body. Although in new-born piglets the amount of body fat is very low (about 2%), its content increases significantly with the animal age (Nürnberg et al., 1998). During pig's life, the most prominent is the accumulation of subcutaneous fat, which at the time of slaughter, may account on average for 60-70% of total body fat, while the rest is distributed in adipose tissue of the body cavities (10-15%) and fat depots between and within muscles. The content of latter, or intramuscular fat (IMF), in most industrial genotypes of pigs is between 2.5 and 3.5% (Grebens, 2004). IMF is mainly made of triglycerides stored in adipocytes located along and around the muscle fibres embedded in the connective tissue

sheaths, from the droplets of triglycerides in sarcoplasm, and from phospholipids and cholesterol in cell membranes (Raes et al., 2004). The IMF content affects taste, softness, juiciness, visual and nutritional properties (e.g. fatty acid composition) of meat (Higgs, 2002). Fatty acids (FA) in IMF and other fat depots, can originated from *de novo* synthesis by pig itself and/or direct intake and incorporation of FA from diet (Vernon and Flint, 1988). FA which can be synthesized by the pig are mostly saturated FA (SFA) and monounsaturated FA (MUFA), while polyunsaturated FA (PUFA), such as linoleic (18:2n-6) and α-linolenic (18:3n-3) acid, are deposited in the tissues only after the absorption from dietary fats (Pettigrew and Esnaola, 2001). In meaty genotype pigs, the contribution of *de novo* synthesized FA to fat deposition is relatively small (Sellier, 1998). Present work aimed to determine the relationship between IMF content and FA composition in meat of industrial pig fatteners from the intensive pork production system in Croatia.

Materials and methods

The study was undertaken on a sample (n = 30) of PIC (Pig Improvement Company) industrial pig fatteners (both barrows and gilts; hybrid genotype: PIC C-23 x PIC P-408) produced under the intensive system and slaughtered by standard procedure (electrical stunning, bleeding, scalding, dehairing, evisceration, carcass splitting, SEUROP classification and cooling). Sampling of muscle tissue (*m. longissimus dorsi*) was performed 24 h *post mortem* on cooled right halves at the 8-rib level. The samples were kept frozen at -20 ºC until the chemical analyses. Total fat in muscle was determined according to ISO 1443 (2001) by Soxhlet extraction. The FA composition was determined by gas liquid chromatography using the *in situ* transesterification method (Park and Goins, 1994). The content of FA methyl esters (FAME) was determined using an Agilent Technologies 6890 N (USA) gas chromatograph equipped with a flame ionisation detector and the capillary column Supelco Omegawax™ 320 (length 30 m, internal diameter 0.32 mm and film thickness 0.25 µm) for FAME separation. Separated FAMEs were identified by comparison with the retention times of the FAMEs in a standard mixture (Nu-Chek Prep, Inc., Elysian, USA). The same standard mixture was used to determine the response factor (Rf) for each FA. The mass portion of each FA in the sample was determined using the Rf and the factor of conversion of FA content from the FAME content. Data were processed by descriptive statistics, Pearson's correlation and regression analyses.

Results and discussion

As shown in Table 1, the mean (±SD) live and slaughter weight of analysed pigs was 96.9±11.7 kg and 79.5±10.4 kg, respectively, with 11±5.2 mm of back fat and 67±5.7 mm of muscle thickens and 59.5±4.4% of meatiness. The average content of muscle fat was 12.4±3.7 g·kg^{-1}, what is considered as low IMF content (Hocquette et al., 2010).

Table 1. Descriptive statistics for carcass traits and intramuscular fat (*m. longissimus dorsi*) content of pigs (n = 30)

Trait	Min	Max	Mean	SD	CV (%)
Live weight (kg)	74	121	96.9	11.7	12.1
Slaughter weight (kg)	57	103	79.5	10.4	13.1
Back fat thickness (mm)	3	26	11	5.2	47.8
Muscle thickness (mm)	52	82	67	5.7	8.6
Meatiness (%)	48.4	67.7	59.5	4.4	7.4
Intramuscular fat ($g \cdot kg^{-1}$)	4.7	20	12.4	3.7	30.4

Min - minimum; Max - maximum; SD - standard deviation; CV - coefficient of variability

The FA composition of IMF (Table 2) was dominated by oleic (18:1), palmitic (16:0), linoleic (18:2n-6) and stearic (18:0) acid with an average shares of 33.65±4.26 g, 21.44±1.25 g, 15.23±2.61 g and 14.72±1.96 g per 100 g of total FA, respectively. Such representation of major FA-s is consistent with a general FA profile of pork meat found in literature (Valsta et al., 2005). With regard to relationship between IMF content and FA composition, a significant ($P \leq 0.01$) positive correlation (r) existed between the IMF content and 18:1 (0.71) and 16:0 (0.56), while the negative correlation with IMF had 18:2n-6 (-0.59; $P \leq 0.01$) and 18:0 (-0.43; $P < 0.05$). Accordingly, regression analyse of FA shares on IMF content showed a significant ($P \leq 0.01$) positive regression (*b*) for 18:1 (0.8075) and 16:0 (0.1874), and significant negative regression for the share 18:2n-6 (-0.4129; $P \leq 0.01$) and 18:0 (-0.226; $P < 0.05$). Similar patterns between IMF content and FA composition were established for total MUFA ($r=0.7$, $b=0.794$, $P \leq 0.01$) and PUFA ($r=-0.66$, $b=-0.7642$, $P \leq 0.01$) shares. As argued by Grebens (2004), an increase in IMF content is mainly due to increased triglyceride content while the content of structural PUFA-rich phospholipids is mostly constant. Hence, the decrease of PUFA share that is observed with an increase in IMF content is probably due to a simple dilution of the PUFA content by *de novo* synthesized MUFA and SFA which are the predominant triglyceride constituent. Results of present study on relationship between IMF and MUFA and PUFA corroborates the results of Nuernberg et al. (2005) and Bosch et al. (2012). However, in those works a significant positive relation between IMF and SFA was also reported, what is not established in present study.

Table 2. Descriptive statistics for intramuscular fatty acid composition (g·100 g^{-1} of total fatty acids), correlation between muscle fat content and fatty acids, and regression of fatty acids on muscle fat content (n = 30)

Fatty acid[1]	Min	Max	Mean	SD	CV (%)	*r*	*b*	R^2
14:0	0.77	1.45	1.09	0.16	14.67	0.62**	0.0261**	0.36
16:0	19.16	24.64	21.44	1.25	5.83	0.56**	0.1874**	0.3
16:1	1.83	3.8	2.63	0.45	17.11	0.57**	0.068**	0.3
18:0	10.74	18.49	14.72	1.96	13.31	-0.43*	-0.226*	0.16
18:1	26.52	41.8	33.65	4.26	12.65	0.71**	0.8075**	0.49
18:2n-6	10.74	20.61	15.23	2.61	17.13	-0.59**	-0.4129**	0.33
18:3n-3	0.34	0.7	0.44	0.09	20.45	NS	NS	
20:4n-6	3	8.58	4.84	1.33	27.47	-0.68**	-0.2407**	0.44
20:5n-3	0.29	0.94	0.55	0.16	29.09	-0.54**	-0.029**	0.47
∑ SFA	35.8	40.9	38.3	1.37	3.56	NS	NS	
∑ MUFA	30.6	46.6	38.4	4.24	11.03	0.7**	0.794**	0.48
∑ PUFA	15.8	33.6	23.3	4.38	18.83	-0.66**	-0.7642**	0.41

Min - minimum; Max - maximum; SD - standard deviation; CV - coefficient of variability; SFA - saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids; [1]Only selected fatty acids are shown; *r* - Pearson's coefficient of correlation, *b* - regression coefficient, R^2 - coefficient of determination; *P≤0.05; **P≤0.01

Conclusions

From the results presented it can be concluded that with an increase in IMF content the share of 18:1 and the total MUFA increased while the shares of 18:2n-6 and total PUFA in pork decreased. Although there was a significant relationship between the IMF content and the majority of individual SFA, the effect of IMF content on the proportion of total SFA in pork was not established. This can be explained by the existence of significant correlations and regressions but with an opposite directions for major SFA-s, which shares in IMF were simultaneously increasing (e.g. 16:0) and decreasing (e.g. 18:0) with an increase in IMF content.

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